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Indian Standard

DETERMINATION OF THE MAXIMUM SYMMETRICAL RADIATION FIELD IN THE RADIATION BEAM FROM A ROTATING ANODE X-RAY TUBE FOR MEDICAL DIAGNOSIS

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NEW DELHI 110002

Gr 3

March 1987

Indian Standard

DETERMINATION OF THE MAXIMUM SYMMETRICAL RADIATION FIELD IN THE RADIATION BEAM FROM A ROTATING ANODE X-RAY TUBE FOR MEDICAL DIAGNOSIS

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Indian Standard

DETERMINATION OF THE MAXIMUM SYMMETRICAL RADIATION FIELD IN THE RADIATION BEAM FROM A ROTATING ANODE X-RAY TUBE FOR MEDICAL DIAGNOSIS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 27 August 1986, after the draft finalized by the Electromedical Equipment Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This standard describes a method for the determination of the greatest geometrically symmetrical radiation field at a specified distance from the focal spot for which the percentage energy fluence rate along the major axes does not fall below a permitted value.

0.3 While preparing this standard assistance has been derived from IEC Doc : 62B (Central Office) 53 Determination of the maximum symmetrical radiation field from a rotating anode X-ray tube for medical diagnosis.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard applies to X-ray source assemblies and X-ray tube assemblies containing rotating anode X-ray tubes, for use in medical diagnostic radiology for techniques in which the X-ray pattern will be received simultaneously over the image reception area.

1.2 Unless otherwise specified, this standard is applicable to an X-ray tube assembly with a brand new rotating anode X-ray tube.

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*Rules for rounding off numerical values (*revised*).

1.3 This standard does not apply to X-ray source assemblies and X-ray tube assemblies for special applications, when, for example, steeper variations of the energy fluence rate or particular distributions are intended.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions, in addition to the definitions given in IS : 1885 (Part 43)-1977*, shall apply.

2.1 Accompanying Documents — Documents provided with an electrical installation, electrical equipment or accessory and containing important information for the assembler, installer and user, particularly regarding safety.

2.2 Actual Focal Spot — Area on the surface of the target that intercepts the beam of accelerated particles.

2.3 Anode — In any X-ray tube, electrode to which the beam of electrons is accelerated and which normally contains the target.

2.4 Anode Speed — In a rotating anode X-ray tube, angular velocity at which the anode rotates, usually expressed in revolutions per minute.

2.5 Blooming Effect — As a characteristic of the focal spot of an X-ray tube, ratio of star pattern resolution limits obtained under specific measuring conditions.

2.6 Effective Focal Spot — Perpendicular projection of the actual focal spot on the reference plane.

NOTE — The shortened term focal spot refers to the effective focal spot.

2.7 Focal Spot Pinhole Radiogram — Radiogram obtained by means of a pinhole camera, showing the shape, orientation and the spatial distribution of radiant intensity of the radiation emitted across an effective focal spot.

2.8 Focal Spot Slit Radiogram — Radiogram obtained by means of a slit camera, showing the distribution of radiant intensity in the direction normal to the length of the slit, of the radiation emitted across an effective focal spot.

2.9 Focal Spot Star Radiogram — Radiogram obtained by means of a star pattern camera, for the determination of the star pattern resolution limit in one or more directions across an effective focal spot.

---

*Electrotechnical vocabulary: Part 43 Electrical equipment used in medical practice.

2.10 Focal Track — In a rotating anode X-ray tube, part of the anode which is struck by the beam of electrons during rotation of the anode.

2.11 Intensifying Screen — Layer of suitable material or substance used in direct radiography to intensify the action of incident X or gamma radiation upon a radiation sensitive emulsion.

2.12 Irradiation Time — Duration of an irradiation determined according to specific methods, usually the time a rate of a radiation quantity exceeds a specified level.

2.13 Loading Factor — Factor influencing by its value the X-ray tube load, for example, X-ray tube potential difference and its percentage ripple, X-ray tube current, loading time, equipment anode input power.

2.14 Loading Time — Time, determined according to a specified method, during which the anode input power is applied to the X-ray tube.

2.15 Maximum Potential Difference — Highest permitted X-ray tube potential difference for specific operating conditions and for a specified rectification of the potential difference.

2.16 Modulation Transfer Function — As a characteristic of the focal spot of an X-ray tube, absolute value of the folurist transform of the one-dimensional distribution of radiant intensity emitter across the effective focal spot.

2.17 Nominal Anode Input Power — Highest constant anode input power may be applied for a single X-ray tube load in a specific loading time.

2.18 Nominal Focal Spot Value — Dimensionless numerical value having a specific relation to the dimensions of the focal spot of an X-ray tube, measured under specific conditions.

2.19 Non-Screen Film — In direct radiography, radiographic film for use without an intensifying screen.

2.20 Normal Use — Operation, including standby state, according to the instructions for use or for the obvious intended purpose.

2.21 Pinhole Camera — Assembly of equipment to obtain by means of a pinhole diaphragm a focal spot pinhole radiogram on radiographic film.

2.22 Radiographic Film — Sheet or roll material consisting of a transport carrier covered with radiation sensitive emulsion on one or usually both sides and designed for use in direct radiography.

2.23 Radiographic Rating — For the operation of an X-ray tube, specified combination of conditions and loading factors under which the specified limits of loadability of the X-ray tube are attained.

2.24 Reconstructive Tomography — Indirect radiography in which the information is obtained by measurement of the attenuation of a small radiation beam scanned across the object in various directions.

2.25 Reference Axia — For a radiation beam, line in the reference direction through the centre of the radiation source. For a symmetrical radiation beam, the centre of the radiation field coincides within required tolerances with the reference axis of the radiation beam.

2.26 Reference Direction — For a beam of ionizing radiation, specified direction to which the target angle, the radiation field size and specifications with respect to the imaging properties of the radiation source are related.

For an X-ray beam, direction to which the anode angle, the nominal focal spot value, the X-ray field size and specifications with respect to the imaging properties of the focal spot are related.

2.27 Reference Plane — For an effective focal spot, plane perpendicular to the reference direction containing the point at which the reference axis intersect with the actual focal spot.

Usually, the point of intersection forms the intended centre of symmetry of the effective focal spot.

2.28 Rotating Anode X-Ray Tube

2.29 Slit Camera — Assembly of equipment to obtain by means of a slit diaphragm a focal spot slit radiogram on radiographic film.

2.30 Specifique — When used as an adjective in combination with parameters or conditions referring to a particular value or standardized arrangement, usually to those required in an IEC standard.

2.31 Specified — When used as an adjective in combination with parameters or conditions referring to a value or arrangement to be chosen and indicated for the purpose under consideration.

2.32 Star Pattern Camera — Assembly of equipment to obtain by means of a test pattern a focal spot star radiogram on radiographic film.

2.33 Star Pattern Resolution Limit — As a characteristic of the focal spot of an X-ray tube, highest spatial frequency which can be imaged under specific measuring conditions.

2.34 Target — That part of an X-ray tube or a particle accelerator onto which is directed a beam of accelerated particles to produce X-ray or neutron radiation.

2.35 X-Ray Tube — Evacuated vessel for the production of X radiation by the bombardment of a target, usually contained in an anode, with a beam of electrons accelerated from a cathode by a potential difference.

2.36 X-Ray Tube Assembly — X-ray tube housing with an X-ray tube installed.

2.37 X-Ray Tube Current — X-ray electric current through the anode of X-ray tube.

The X-ray tube current is expressed by its mean value in milliampere (mA).

2.38 X-Ray Tube Housing — Container for an X-ray tube providing protection except for the radiation aperture, against electric shock and against X-radiation. It may optionally contain other components.

2.39 X-Ray Tube Load — Electric energy supplied to an X-ray expressed by a combination of values loading factors.

2.40 X-Ray Tube Potential Difference — Potential difference applied to an X-ray tube between the cathode, the electron emitter, and the anode.

3. ENERGY FLUENCE RATE

3.1 Due to the increased absorption in the anode of an X-ray tube in oblique directions, the energy fluence rate decreases towards the edge of the radiation field in directions forming small angles with the surface of the anode.

In addition the energy fluence rate over the radiation field decreases with distance from the reference axis to the edges of the radiation field according to the inverse square law.

Absorption in the material of the target affects radiation quality as well as energy fluence rate; therefore the results of measurements of energy fluence rate are affected by the amount of additional filtration in the radiation beam. For this reason the measuring arrangement required in this standard includes substantial additional filtration of a given value in the radiation beam.

3.2 Further the distribution of energy fluence rate is affected by, for example:

a) Scattered radiation from objects in the radiation beam, and

b) The position of any object in the radiation beam.

Therefore, the measuring arrangement is required to have no objects in the radiation beam except the added filter in its required position.

3.3 A typical distribution of the energy fluence rate along the major axes is shown in Fig. 1.

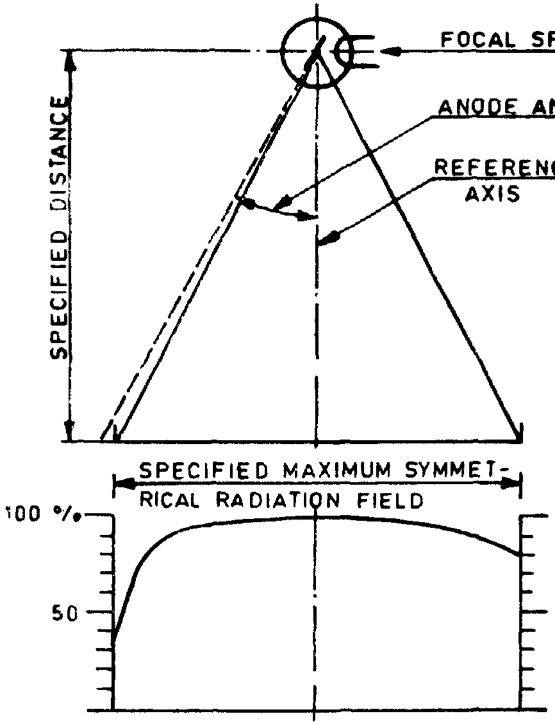

Fig. 1 Typical Distribution of the Relative Energy Fluence Rate Along the Major Axis X of A Maximum Symmetrical Radiation Field

4. MAXIMUM SYMMETRICAL RADIATION FIELD

4.1 Orientation of the Maximum Symmetrical Radiation Field — For the determination of the maximum symmetrical radiation field the distribution of energy fluence rate will be measured along two major axes in the measuring plane.

4.1.1 The major X-axis is the projection in reference direction of the longitudinal axis of the X-ray tube assembly parallely shifted into the focal spot.

The major *Y*-axis is normal to the *X*-axis.

Both major axes intersect on the reference axis.

The orientation of the maximum symmetrical radiation field is shown in Fig. 2.

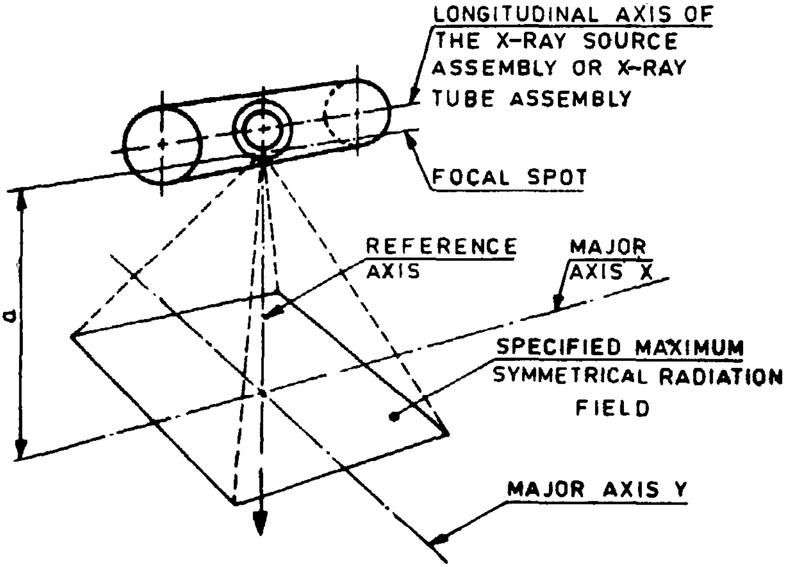
LONGITUDINAL AXIS OF THE X-RAY SOURCE ASSEMBLY OR X-RAY TUBE ASSEMBLY
FOCAL SPOT
REFERENCE AXIS
MAJOR AXIS X
SPECIFIED MAXIMUM SYMMETRICAL RADIATION FIELD
MAJOR AXIS Y
d

FIG. 2 ORIENTATION OF THE MAXIMUM SYMMETRICAL RADIATION FIELD

4.1.2 If the limitation of the radiation field owing to the anode angle (Heel effect) follows a line in a direction other than normal to the longitudinal axis of the X-ray tube assembly, the major *X*-axis shall be adjusted accordingly.

4.2 Distribution of Energy Fluence Rate — A maximum symmetrical radiation field shall be determined as the dimensions of the greatest radiation field at specified distance from the focal spot symmetrical with respect to the specified reference axis, with its edges parallel to the major axes, in which the distribution of relative energy fluence rate along the major axes does not fall by more than 70 percent of the energy fluence rate on the reference axis.

4.3 Maximum Energy Fluence Rate — At no point along the major axes shall the value of energy fluence rate exceed 110 percent of that on the reference axis.

5. MEASUREMENT OF THE DISTRIBUTION OF ENERGY FLUENCE RATE

5.1 The measurement of the distribution of energy fluence rate shall be made:

a) either by production of a direct radiogram and subsequent densitometric measurement (*see* Appendix A),

b) or by another dosimetric method of comparable resolution.

5.1.1 *Measuring Arrangement* — At a distance of 75 percent of the specified smallest distance, a_{min} of the radiation field from the focal spot an added filter according to Table 1 shall be placed of sufficient dimensions to intercept the entire radiation beam.

The measuring plane shall be at the specified distance(s), of the radiation field from the focal spot and normal to the reference axis to within 0·036 rad (2·06°),

If for a specified special radiodiagnostic technique the 'image receptor plane' is not normal to the reference axis the measuring plane shall be adjusted to normal to the direction specified for that technique to within 0·036 rad (2·06°).

In general, the measuring arrangement shall be so as to minimize scattering and back-scattering.

The measuring arrangement laid down is as shown in Fig. 3.

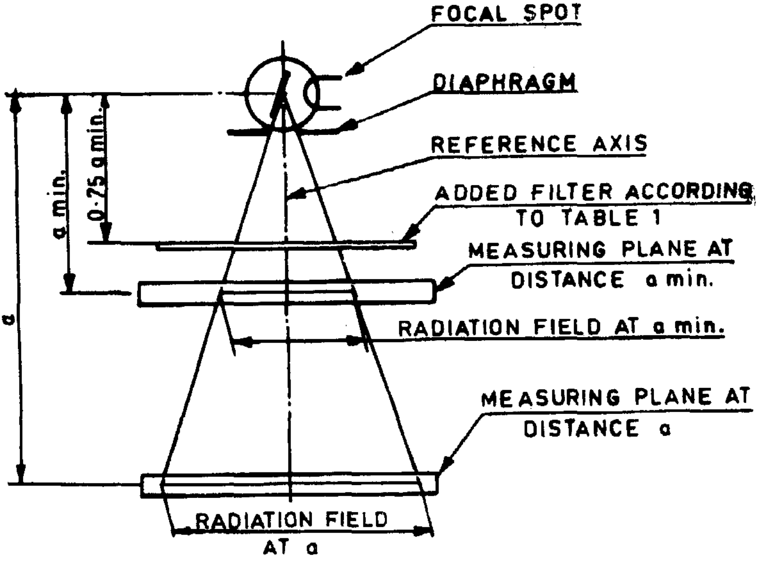
FOCAL SPOT
DIAPHRAGM
REFERENCE AXIS
ADDED FILTER ACCORDING TO TABLE 1
MEASURING PLANE AT DISTANCE a min.
RADIATION FIELD AT a min.
MEASURING PLANE AT DISTANCE a
RADIATION FIELD AT a
a min.
0·75 a min.
a

FIG. 3 MEASURING ARRANGEMENT

5.2 Measuring Conditions — The anode of the X-ray tube shall rotate.

The X-ray tube voltage shall be as given in Table 1.

TABLE 1 RADIATION QUALITY

(*Clause* 5.1.1)

NOMINAL X-RAY TUBE VOLTAGE U max kV (1)	ADDED FILTER THICKNESS OF *ALUMINIUM* mm (2)	REQUIRED X-RAY TUBE VOLTAGE U kV (3)
$30 \leqslant U\text{max} \leqslant 50$	5	30
$50 < U\text{max} \leqslant 75$	10	50
$75 < U\text{max} \leqslant 125$	20	75
$125 < U\text{max}$	20	75 and 125

The dosimetric and densitometric conditions shall be so that a refinement of the detector system would not result in a significant change of the dimensions determined.

6. COMPLIANCE

6.1 Assessment of Compliance — Along the major axes of a specified maximum symmetrical radiation field no relative value of energy fluence rate determined according to **5** shall be lower than the value resulting from the requirement of **4**.

6.2 Statement of Compliance — If compliance with this standard is to be stated, at least the indication of the maximum symmetrical radiation field shall be given that corresponds to the smallest distance from the focal spot that is specified for the X-ray source assembly or X-ray tube assembly.

The statement of a maximum symmetrical radiation field complying with this standard shall be done as follows:

Maximum symmetrical radiation field	...mm/...mm
at a distance from the focal spot of	...mm

Combinations of radiation fields and distances may be given in the form of a table or curve.

NOTE — Values for the maximum symmetrical radiation field and its distance from the focal spot, where the first value for a rectangular radiation field shall be in the direction parallel to the longitudinal axis of the X-ray source assembly or X-ray tube assembly (*see* Fig. 2).

APPENDIX A

(*Clause* 5.1)

DETERMINATION OF ENERGY FLUENCE RATE BY RADIOGRAPHIC DENSITOMETRIC MEASUREMENT

A-1. RADIOGRAPHIC FILM

A-1.1 The radiographic film shall be a non-screen film of a type whose gradient of the sensitometric curve is linear at least from a diffuse transmission density of 0·5 up to 1·6. The radiographic film shall be large enough to extend up to 105 percent of the Radiation field in each direction.

A-2. IRRADIATION CONDITIONS

A-2.1 The radiographic film shall be exposed so that after full development a local diffuse density between 1·0 and 1·4 is obtained in the areas of greatest blackening.

A-3. MEASUREMENT OF BLACKENING

A-3.1 The direct radiogram obtained shall be scanned by means of a densitometer. Neither the width nor the length (nor a circular diameter) of the slit of the densitometer shall exceed 2 mm.

A-4. DETERMINATION OF ENERGY FLUENCE RATE

A-4.1 The values of density above base and fog shall be transformed into values of energy fluence rate by means of a sensitometric curve for the film material used. The sensitometric curve shall be established using an identical film exposed under essentially the same conditions and processed under the same conditions as those used for the production of the direct radiogram.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

QUANTITY	UNIT	SYMBOL
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

QUANTITY	UNIT	SYMBOL
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

QUANTITY	UNIT	SYMBOL	DEFINITION
Force	newton	N	1 N = 1 kg.m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2